The 'new' CSIR — promise fulfilled or opportunities lost?

The radical reorganization of the CSIR, the largest scientific research establishment in Africa, in recent years, as a result of changed operational and financial objectives, has had important consequences for the practice of science and technology in this part of the world. The article beginning on this page argues that these changes have generally not been in the best interests of science, whereas that starting on page 15 contends that the restructuring was necessary in order to make the most of the available expertise and resources in the prevailing economic conditions.

Whatever one's assessment, these articles help to explain the rationale behind the changes, what the financial consequences have been, and how the CSIR should be considered in the years to come.

Commercializing the CSIR and the death of science

J.R.E. Lutjeharms and J.A. Thomson

The dramatic organizational and cultural changes that have been made over the past few years in the largest scientific organization in Africa, the South African CSIR, have attracted some positive comment from the commercial community in South Africa. To date, only a few subdued cautionary noises have been heard from individuals in the scientific community. We believe, now that the new structure and policy have been in operation for 4 years, and most of the dust has settled, it is an opportune time to assess critically what has been wrought.

We look here briefly at the new philosophy, the new structure, the management style and some preliminary results. We come to the conclusion that the present financial position of the 'new' CSIR suggests only ambivalent success in attracting funds from the private sector, the central rationale for the whole restructuring. We also conclude that this restructuring has been achieved at the expense of the entire scientific enterprise within the CSIR.

This has important consequences for South African science as a whole as well as for South Africa's ability to meet technological challenges in the 21st century.

The old CSIR

The Council for Scientific and Industrial Research was established in 1945 with the express aim of bringing into existence a South African national research organization to address national technological problems and to serve as a central scientific powerhouse.[1] To this end National Laboratories for the basic sciences such as physics and chemistry formed the cornerstones of the new structure. Other institutes, such as the National Building Research Institute, were multidisciplinary and industry orientated.

Over the years, as industries and the State identified certain scientific or technological problems and recognized the CSIR's potential ability to investigate them, numbers of requests for directed research were passed to the CSIR. If such research grew to the extent that an independent research institute was called for, such an institute was then allowed to develop in a natural and organic way[1] from the existing mother laboratories. In this way, for instance, institutes for mechanical engineering, mathematical sciences and oceanology were all in time offshoots of the National Physical Research Laboratory.[2] Institutes for timber research as well as road and transport research were in a similar way closely associated with the National Building Research Institute before achieving their independence.

As the managerial competence of the CSIR and its administrative infrastructure grew, more research groups and laboratories that hitherto had been independent were placed under the CSIR's umbrella as the recognized national scientific and technological research establishment. These included groups working on timber, wool, textiles and for the fisheries industry.[1]

After 40 years, the breadth and scope of research activities of the CSIR were wide and included an eclectic mixture of both basic and applied sciences. The activities of some institutes were nearly totally directed at the research needs of a particular industry and in some exceptional cases received up to 95% of their funding from such contract research;[3] others only partly so. In the ideal case an institute would have about half its scientists at any time working on external contract work, while the other half would be occupied with more basic research but directed towards aspects that were considered to be of national interest. Undirected basic research, or pure knowledge enhancement, hardly ever exceeded 10% or so of the total budget.[4]

The CSIR thus filled an important research niche between the more esoteric basic research carried out at academic institutions and the narrowly focused product research of factory laboratories. Although scientists and engineers could spend a significant amount of time on contract research, as soon as the contract aims had been achieved they could return to their basic science. In this way government departments and industry were assured that research contracts would be dealt with by scientists who remained at the cutting edge of their particular fields. In international management circles it has been recognized that the best scientists seek their peers[5] and want to be where the talent is, so they can do the best work. The CSIR policy allowed this to happen and successfully attracted large numbers of excellent scientists not only from South Africa but also from abroad.

Disciplinary institutes, such as the National Physical Research Laboratory, covered a broader range of subjects in their respective disciplines than any university could manage, and maintained a number of long-term projects of a type unlikely to be found in any academic institution.[2] Many of these were deemed to be of direct national interest or value. National laboratories are highly rated and are maintained in the US[6] and many other countries for these same reasons and for their ability to maintain efficiently large multidisciplinary projects that are difficult to run anywhere else.

For lack of a better body, the CSIR was also selected by the government to foster research at universities, first

---

Profs Lutjeharms and Thomson are respectively heads of the Ocean Climatology Research Group in the Department of Oceanography and of the Department of Microbiology at the University of Cape Town, Rondebosch 7700, South Africa.

through the Universities Grants Committee and lately the Foundation for Research Development.[1] Perhaps in not quite so obtrusive a way the CSIR also played an important supportive role for the national research effort through its vast and excellent infrastructure. Through maintaining the largest scientific library in the country and the best scientific workshops, it served the wider scientific community.

As the recognized national focus of South African research, the CSIR in many ways also represented South African science to the outside world. The CSIR was, for instance, South Africa's national member in the ICSU (International Council of Scientific Unions). Further, by maintaining science liaison offices at a number of key centres abroad it encouraged exchange and interaction between top scientists of these countries and their counterparts in South Africa. The president of the CSIR was for many years recognized by the media as the *de facto* spokesman for South African science.[7] By 1985/86 up to 13% of all research in Africa was being carried out by the CSIR.[8]

By the middle eighties, some people outside the CSIR had started to express reservations about certain tendencies they thought to perceive in the organization. Particularly at universities, some national laboratories were seen as lethargic, aimless and hampered by increasing layers of bureaucracy and red tape. Industry on occasion viewed some of the research being carried out as irrelevant to their particular needs. The impression was created that contract research came to many CSIR employees as an unwelcome interruption to their basic research and was not handled expeditiously. In general, research, even in laboratories supposedly serving industry, was seen as not particularly well focused on market needs. Much of this criticism had a solid basis. After 40 years, bureaucracy had overgrown much of the enterprise and a stultifying 'civil service' attitude of rules, regulations and forms-in-triplicate was to some extent prevalent.

A major change in direction

During the last few years the CSIR has been totally transformed so that little remains except the name. (Even the name CSIR now no longer stands for Council for Scientific and Industrial Research but by law[9] is a sobriquet, the letters of which do not have any further significance.) The history of these changes is significant since it was responsible for the present situation and may hold some important lessons.

In May 1985 a White Paper on a national strategy for industrial development was tabled in Parliament. In it there was an explicit proposal identifying the CSIR as the most likely agent for a process of technology transfer from research establishments to industry. The first intimations to most of the scientific community of the coming revolution in the CSIR was a newspaper report on a debate in Parliament on 16 April 1986, in which the MP for Pretoria-East, Dr Theo Alant, voiced the opinion that South Africa was investing too much money in basic research.[10] He expressed doubt whether the country could afford to pay for research that was not directed at mineral exploration, development of industry or at the creation of jobs. He furthermore suggested that the CSIR was not the appropriate body to evaluate and fund university research, since 'it is in direct competition with universities for state funding', and asked the question whether state contributions to the CSIR should not be reduced to force the CSIR to become more industry orientated. Some of these concepts were subsequently worked out in greater detail.[11]

This speech precipitated a lively debate in the letter columns of *Die Burger* on the respective roles of basic and applied science[12-21] and on an appropriate science policy for South Africa. It is perhaps significant to note that all the 'questions' posed by Dr Alant have subsequently become addressed as official policy[9] which has been instituted.[22]

In reaction to these developments, the CSIR, in March 1986, appointed a firm of commercial management consultants to draw up a strategy for its future course and in October of 1986 the CSIR published this new strategy, after approval by its Council. By March 1987 the restructuring thought to be required for the organization by the new strategy was launched.[22] By August a new top management took up its position and in March 1988 the 'new' CSIR was officially launched, the restructuring having been completed and a new 'culture' inculcated in its employees.

What did this restructuring entail? First, the 23 research institutes, some with an enviable scientific tradition, were scrapped and replaced by 11 divisions, or 'strategic units', each aimed at the perceived needs of a 'market segment'. Scientists in the core disciplinary laboratories, such as the National Physical Research Laboratory and that for Chemistry and Mathematics, were placed in 'market orientated' groups where it was thought that their expertise might come in useful. In some cases cohesive research groups that could justify their continued existence by identifying potentially remunerative 'market niches' remained intact; in many cases research groups were disbanded and their members distributed amongst different 'strategic units'. New groups or programmes now retain no disciplinary cohesion but consist of any individuals that are thought to be required for specific contract work.

A 'flat' management structure was created consisting of young incumbents only. With the demise of many institutes and also layers of management, a substantial number of senior scientific managers became redundant or were asked to take early retirement. (It is of interest that this policy has subsequently been reversed. Additional levels of management have been reintroduced. Scientific managers previously made redundant have not, however, been reappointed.)

Notwithstanding claims about the need for 'participatory management' in the new CSIR, management made it abundantly clear that no criticism or discussion of the basic philosophy underlying the policy changes was welcome. Employees were, however, involved in innumerable information meetings, group sessions, strategy sessions, marketing, leadership, team-building, as well as management courses, and in this way were very well informed on the new philosophy and its implications. These gatherings included a strong element of inculcation of a 'market-orientated culture'. Middle management scientists were required to get acquainted with and use a whole new commercial jargon. Even scientists at grassroots level were required for each project proposal to identify 'market share', 'competitors', 'strategic positioning', 'market trends', 'strategic thrusts' etc. in order to get funding. New remuneration packages based on a commercial evaluation system were designed in concert with a new set of conditions of employment.

As part of the 'strategic thinking', so-called competitors had to be identified. In many cases these were erstwhile colleagues in state departments, other statutory organizations, universities and the private sector. In some 'strategic units' individuals were given the specific task to 'effectively neutralize' such competitors. In some 'strategic units' scientists were told that henceforth publication of research results in the scientific literature would be discouraged, since it would lead to 'competitors stealing our ideas' and, furthermore, that co-operation with colleagues at universities would be frowned upon by management for the same reason.

The media on the whole showed only

cursory interest in these events that were having a dramatic impact on the scientific community. A few scientists in the employ of the CSIR, writing under pseudonyms, complained in the press that the CSIR's scientific ability was being destroyed.[23–25] The retrenchment of two deputy presidents, six chief directors and early retirement for six others did make headlines in the printed media, such as: 'CSIR retrenches and hires' and 'CSIR "revolution" will produce major changes'.[26,27] In general the reaction of the more thoughtful part of the media fell into two clearly defined groups:[28–30] the commercial sector, which was mildly and carefully supportive of the new direction, and the cultural sector, which was more critical.[31–33]

A trade journal, *Engineering Week*, went so far as to choose the 'new' CSIR as the Company (sic) of the Year. Its motivation for doing this is instructive.[34] It paid tribute 'to the success achieved in transforming a government body into a member of the South African private sector'. It claimed that the CSIR's 'old academic image' had been replaced by that of 'a thriving, free-market based, commercial problem-solving centre'.

The philosophy of 'a market orientation' for science on which these radical changes to the CSIR were being built was not entirely original or novel. It had previously been in vogue in Britain, the US and elsewhere, where it had more or less reached the end of its natural lifetime.

In Britain, scientists had bemoaned government decisions to treat scientific research as a service, to be provided by a contractor for a customer. Scientists had been forced increasingly to rely on short-term commissioned projects, which was demonstrably bad for the continuing health of research.[35] This policy was, unlike in South Africa, widely and loudly criticized by such notables as the president of the Royal Society[36] for implying that the government was thinking that the management of scientific creativity is no different from the management of chain stores or the running of betting shops. By the end of 1989 the pendulum had swung. The then prime minister, Mrs Margaret Thatcher, was quoted as saying:[37] 'The greatest economic benefits of scientific research have always resulted from advances in fundamental knowledge rather than the search for specific applications.'

Similarly, in the United States the Reagan administration had come into office sternly demanding that scientists set their own rigid national research priorities before applying for limited state funding, with the implied threat that otherwise the state would be forced to do it for them. By 1987 the wheel had also turned here and President Reagan called basic research the cornerstone of US competitiveness, and proposed tripling the National Science Foundation's budget.[38]

This world-wide swing from a strong 'market orientation' in the funding of scientific research back to a focus on basic science had reached different parts of the cycle in different countries at the time the CSIR was going through its internal revolution. In Germany the Bundesministerium für Forschung und Technologie presented its comprehensive programme for 1987, in which it now considered its first and foremost priority to have fewer market-orientated technology projects and to fund more basic research. Meanwhile, in the People's Republic of China, the overemphasis on the commercialization of research activities and the attempt to use administrative measures to coerce scientists into playing the role of businessmen, was seen by some to be extremely short-sighted, to do profound damage to that nation's science and technology base, and to play a major role in the unwillingness of Chinese students abroad to return home.[39]

No wonder some South African scientists were bemused by the strange bedfellows South African makers of science policy, particularly for the CSIR, had selected. The impression gained by outsiders was that the CSIR was, somewhat belatedly, following a trendy global fashion in research funding without taking cognizance of mistakes made and lessons learnt elsewhere.

Effect on employees

The immediate effect of this radical discontinuity in the ethos, management and culture of the CSIR was traumatic for most of its employees. According to regular 'attitude audits' carried out in the CSIR, it has taken 3 years before the majority of employees again felt more positive than negative about the CSIR. The new culture and structure has now, after 4 years, solidified and the impact of this huge experiment may be discerned.

First, the very flat management structure has engendered an increase in micromanagement down to the lowest levels. Researchers experience such a new load of administration that communication has been neglected. 'Communication audits' in the CSIR[40] show that there is a general perception that bureaucracy under the new regime has increased instead of diminished. Project leaders are in practice expected to a large extent to carry out their own marketing, public relations, personnel management, financial management and to establish contact with firms in the private sector who might become 'partners' in their research endeavours. This has been a major adjustment for many researchers, not all of whom have been able to cope. In a number of cases where researchers have successfully undergone this personal transformation, they have left the CSIR to set up shop for themselves with large personal remunerative advantage.

Since all groups as well as individuals are regularly judged by financial returns or potential returns, a survival-mode way of thinking has been brought down to the smallest group, leading to what may best be called a 'fast-buck syndrome'.

The new management style, restructuring and change in mission of the CSIR have had as one result that the turnover in employees has rapidly increased, from less than 8% per year to a peak of nearly 18% per year in 1989, the year after the changes were instituted (see Fig. 1). It has subsequently come down to an average for all employee categories of 15%, but has not again reached the low values of the old system. Furthermore, the turnover in the vital categories, for an R & D organization, of scientists and engineers is far higher than the average, in 1988/89 coming close to 20% per year.[42]

Overall, the number of employees has continuously shrunk (Fig. 1), from a peak in 1987 to a number in 1991 just in excess of that of 20 years before.[44] The growth of about half the lifetime of the CSIR, as far as number of people is concerned, has therefore been eroded in the last 4 years. An analysis of the categories from which most people left the CSIR shows that the second largest is that for scientists, the third technicians and the fourth engineers.[41]

Management success

Managing the transformation of the CSIR was carried out with tremendous verve, energy and dedication. Changing the research philosophy of the staff to a strictly technology-oriented one can only be considered a resounding and remarkable success. The commercial thinking now established within the new CSIR is perhaps best exemplified by the language used in CSIR documents:

> Programmes have been directed to give a more directed thrust to position the group towards future markets ... our main aim is to position ourselves to address the thrusts identified ... we have total buy-in from participants ... a strategic marketing thrust will remain a key marketing area in the strategic unit in order to adapt to the continually changing and shifting marketplace ... alignment to the market and customer care are to increase market share.

Many of the new policies and managerial philosophies contrast sharply, however, with the best modern thinking in managerial science. This raises considerable concern about the medium- to long-term viability of the new CSIR as a commercial undertaking. A few examples will suffice.

In a March 1989 interview, the CSIR's 'human resources executive', Mr Fred Camphor, stated: 'People will no longer be paid according to their rank. Individuals who perform must be rewarded. And conversely, poor performers will not be rewarded. It's called monitoring productivity and efficiency'.[44] William Deming, the management consultant probably most directly responsible for Japan's post-war economic success, calls the effects of such merit rating devastating.[45] He claims that it nourishes short-term performance, annihilates long-term planning, builds fear, demolishes teamwork and stimulates rivalry and politics. He has stressed other factors detrimental to productivity that all seem to apply in varying degrees to the new CSIR management policy, namely: lack of constancy of purpose (frequently changing mission statements), emphasis on short-term profits (judging proposed research projects by immediate financial return), mobility of managements (continual restructuring), and use of visible figures (judging productivity by budgets only).

The new CSIR prides itself on the efficient manner in which each project is managed by budgetary measures. Specific 'milestones' are set beforehand at which certain 'deliverables' have to be produced before money is paid into the budget for that project. According to international management consultants that have investigated successful firms, this thinking has long ceased to be useful.[46] They decry attempts to use budgeting for long-range forecasting and for trying to set hard numerical targets on the basis of such forecasts.

In a study of transformations in companies, two eminent management consultants[46] come to the conclusion that would-be major-change managers should concentrate on changing those things in an organization that seem easy first, and to go after the larger changes only later, if they want to avoid problems in the medium and long term. This, clearly, is not the way in which the restructuring and realignment of the CSIR were achieved. In his book *Innovation*,[5] Richard Foster gives a number of examples of companies that have attempted cultural changes too fast and suffered subsequent demise in consequence. The major factor in such unsuccessful changes has usually been the long lag-time in changing individuals' skills.

Financial success

Probably the key question concerning the success of the restructuring of the CSIR is one which addresses the growth in contract funding since 1988. This is set out in rounded figures in Table 1, for the financial years 1986/87 to 1990/91.[4,41–43] Whereas the total contribution from contract income was R80 million in 1986/87, before the change, by 1990/91 it had risen sharply to R213 million. The biggest increase occurred during the two years 1988 and 1989, pointing to the effective way in which CSIR employees' thinking had been changed to a market orientation during this period and the success in acquiring outside contracts that resulted. Highly significant is the fact that the parliamentary grant was not frozen, as had been expected. Instead, it consistently rose in each year with percentage increases varying between 4 and 21%.

Most important, however, in judging the financial success would be to evaluate the growth in contract income as a percentage of total income over this period. Suggestions that an 85% outside income could be raised by 1995 were soon shown to be totally unrealistic. A lowered target of 65% now also seems probably out of reach. Contract income has in fact risen only very modestly from 33% in 1986/87 to 44% in 1990/91.[4,41–43] Important to note, however, is that with the acceptance by parliament of the new CSIR statutes,[9] capital can now be invested for an additional source of income. The 44% outside income for 1990/91 is thus an overestimate for contract income since it includes interest on investment. Actual contract income in 1990/91 thus was only 38% of the total, a rise of but 5% over a 4-year period.

This can in no way be considered a resounding financial success. Notwithstanding a drastic restructuring, a massive re-education of its employees and a very expensive media campaign, decreased dependence of the new CSIR on its parliamentary grant has only been marginal. Had the parliamentary grant been frozen at 1988 amounts, as had been suggested in the White Paper, the percentage growth in income from outside contracts would have been considerably larger. It is doubtful whether the CSIR would have survived such a freeze, however.

Table 1. CSIR budgets during commercialization.

Financial year	Parliamentary grant	Contracts etc.	Total
1986/87	R162m (67%)	R80m (33%)	R242m
1987/88	R196m (64%)	R109m (36%)	R305m
1988/89	R220m (59%)	R150m (41%)	R370m
1989/90	R255m (57%)	R195m (43%)	R450m
1990/91	R266m (56%)	R213m (44%)	R479m

(from CSIR Annual Reports.[4,41,42,43])

It may be argued that in many respects the commercialization of the CSIR could not have come about at a worst possible time, since South Africa's economy has been in its longest economic recession since the Second World War. This clearly would have a decisive impact on the willingness of industry to invest in contract research. The recession only 'took hold', however, in the 1989/90 financial year, and would therefore be evident in the figures shown in Table 1 only for 1990/91. The most detrimental effect of the recessive economy on the ability of the CSIR to attract contract funds is therefore probably still to come.

Comparing the modest rate of increase in outside income to the steady, and greater, rate of decline in the number of employees (Fig. 1), it is clear that to maintain its present complement of workers, state subsidy will have to increase steadily and the rate of gaining contract income will have to accelerate substantially. A linear extrapolation of tendencies over the last few years (Fig. 1) suggests that if present trends continue, the CSIR will achieve an 80% contract income only by the year 2002, but that the last CSIR employee would also have left that year! Clearly this is statistical nonsense, but it does dramatize present trends.

Internal finances furthermore exhibit unsuccessful attempts at bringing costs down. Pay for equivalent grades in the CSIR, for instance, is still substantially higher than for the same levels at the best South African universities. Overheads in the CSIR moreover are still amongst the top 25% for similar establishments in South Africa.

Technology and implementation success

One of the major tests to be applied to any 'market-orientated' technological research establishment is the number of patents that are produced per annum. It is a general rule-of-thumb for technological research that for every 10 novel ideas, only one will eventually result in a patent and that for every 10 patents, only one will result in a financially successful product.

It would probably be unfair to judge the prowess of the newly constituted CSIR in this regard after only 4 years. It might instead be valuable to investigate

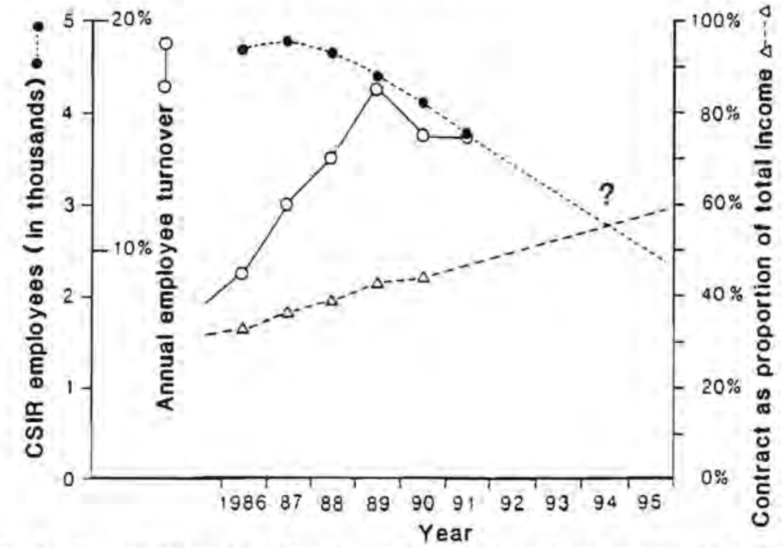

Fig. 1. Changes in number of employees (●), annual employee turnover (○) and contract income as a percentage of total income (△) during the commercialization of the CSIR. Figures are from CSIR annual reports.[4,41,42,43]

the history of results gained by a similar, but older, establishment such as the Industrial Technology Research Institute (ITRI) of the Republic of China. One might well consider this Chinese establishment as the ideal role model for the new CSIR, since it fulfils all the requirements of market orientation and technology transfer strived for by the management of the CSIR. What does the ITRI consist of, and what have been its achievements?

This Institute consists of a number of laboratories each addressing the needs of a clearly defined technology sector. Its aim is to undertake applied research with the mission of accelerating the development of industrial technology.[47] It was chartered in 1973 and has seen continuous growth ever since in its funding both from government as well as from industry. It has also seen continuous growth in its personnel, of whom in 1989[47] 5% held doctoral degrees, 29% masters and 51% bachelors and associate degrees; therefore, 85% are graduates. This is substantially better than the present CSIR staff complement as well as its current financial trends, probably placing ITRI in a much more advantageous position.

Bearing this in mind, it is instructive to apply the criteria of patents per year in judging the effectiveness of the ITRI. This is shown in Fig. 2. It is evident from this curve that the number of patents filed per year has become appreciable only after 1986, i.e. 13 years after the establishment of ITRI. A number of factors might play a role here, but one of the major ones is probably the long time-lag between initiation of technological research and final fruition in the form of a patent. Peter Drucker, professor emeritus of management of the Graduate Business School of New York University, has already pointed out that 'knowledge-based innovations have the largest lead time of any innovations'.[48]

This would seem to be at odds with the new CSIR's philosophy of rapid return on investment. The president of the CSIR, Dr Brian Clark, is for instance on record as stating:[49] 'While it may take decades to achieve a scientific breakthrough, the demand is (now), for quicker returns on investment in research'.

There is no argument that the new CSIR no longer sees itself as playing a role in basic or fundamental science in South Africa. It will, however, undertake longer-term investigations which it considers as having a high likelihood of producing a product that possesses marketability or commercial viability. It is in this regard instructive to see how the role of basic science in technological R & D is seen by international writers on innovation and on successful commercial enterprises.

In his major study on successful innovation,[5] Richard Foster places great emphasis on the crucial need for new products to rest firmly on a scientific understanding of the processes involved. He urges companies to invest in such scientific information before a project begins. He claims that because many US companies do not invest enough in basic research, they know that things work, but do not know why they work, and then become the prey of companies with solid basic research that do. He says (p. 260): 'The best companies have set out a deliberate, well-focused program of internal — or external — acquisition of fundamental scientific research'.

The renowned US consultancy firm of Arthur D. Little Inc. has carried out an international study of innovation and investigated a large number of case studies to establish how managerial leadership has created commercial innovations that have swept the world.[50] Their conclusions are informative but contrary in most respects to the policies advocated and applied in the new CSIR. A few examples: Dr James Black is the discoverer of Tagamet, a substance that has revolutionized the treatment of stomach ulcers. He left ICI because that company was interested in making drugs, whereas Black was interested in proving a basic scientific theory. Feeling his creative thinking was being inhibited by the stress on short-term profits, he joined a more enlightened company where his work came to fruition and bore rich commercial dividends.[50]

A very similar example is that of the development of the tomographic scanner, which has achieved global commercial success. Dr Godfrey Hounsfield is the inventor who, in 1972, presented to the medical community the CAT scanner, the

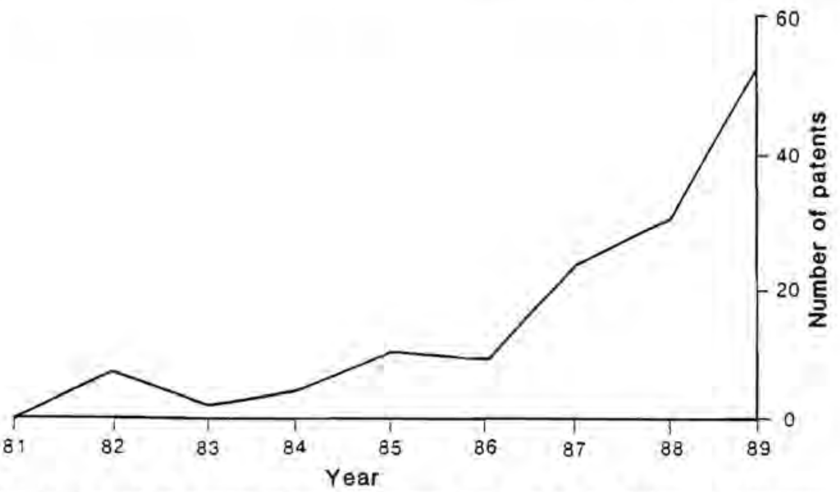

Fig. 2. Growth in number of patents generated per year by the Industrial Technology Research Institute of the Republic of China since 1981.[47]

first computerized tomographic body scanner. His research had been nurtured by Dr Leonard Broadway, who was charged at the EMI company to provide marketable products in new markets. Broadway believed passionately that real freedom of inquiry requires researchers to ignore commercial considerations at the outset and just simply to explore ideas that provoke their curiosity,[50] thus making it possible, against many odds, for Hounsfield to do his work.

The list of case studies that exemplify the crucial role of the ethos of fundamental, basic science in marketable product development seems more or less inexhaustible. The inevitable decline of commercial concerns that have focused on technology for financial gain without considering the need for scientists to be driven by intellectual curiosity alone, is well documented.[50] This augurs very badly for the CSIR, where these needs of scientists are being ignored and their expression strongly discouraged.

Quinn[51] has, for instance, pointed out that some top companies like Genentech and Merck have been built on basic research strategies. They often give scientists more freedom than universities in order to attract top-flight people, allow them to publish extensively, to participate in scientific meetings and to develop a wide external support network of colleagues. Innovative companies recognize that good scientists tend to work for more than just monetary rewards and therefore offer them independence in research. Schmitt, writing on successful corporate research and development in the *Harvard Business Review*,[52] has come to the conclusion that corporate R & D can fail for being dominated by external contracts or customer pressures. Nyak and Ketteringham[50] in turn have established unequivocally that yearning to solve a problem rather than finding a market to exploit is at the heart of what they call breakthrough thinking.

Peter Drucker has furthermore demonstrated that an R & D laboratory, of which the research policy is driven by financial gain, is likely to divert resources from research to gadgetry.[53] Some of the recent products which have been widely touted as demonstrating the new technological bent of the CSIR have included such things as a new peristaltic pump, lamp covers, sweetened egg products, a mobile car washer and security alarm systems. One cannot help but wonder if some of these might not fall in the category of gimmickry, as predicted by Drucker.[53]

All this modern management theory flies in the face of much current thinking and funding procedure within the new CSIR and bodes badly for its future. One is left wondering to what extent the present CSIR is currently living on its scientific capital of the past 40 years and to what extent it is now consuming its seed potatoes without which future crops will be impossible.

The effect on science

The new philosophy pertaining to the scientific endeavour within the new CSIR is perhaps best typified by the following quote from the CSIR president:

> Traditionally scientists have been ... introspective and motivated largely by intellectual curiosity. [It] has reached the point where scientists ... seem to be concentrating on proverbial pin pricks. In today's world [however] scientists are expected to contribute to economic growth.[49]

The logical conclusion from this, and many other similar statements from the CSIR's new top management team, is that scientists are valued members of the new CSIR staff complement as long as their expertise can be harnessed towards some immediate technological aim. Being handmaidens to technology, the final product of their scientific activity, namely publications in peer-reviewed literature, is at best tolerated, at worst discouraged. Even if on occasion publications may be encouraged, in certain CSIR divisions, this is consciously aimed at 'marketability'. Publishing is considered to create an image of scientific reliability.

Measurable results of this restrictive policy have been immediately evident. Scientific publication rates for the CSIR have plummeted to an all-time low. Compared to similar statutory organizations it is very poor, while compared to universities it is abysmal. With no obvious or immediate financial reward to be gained by the establishment or recognition going to the individual, this is not particularly unexpected or surprising.

Well-known colloquium series at erstwhile national laboratories in times past used to attract colleagues from neighbouring universities and, on occasion, hosted eminent foreign scientists. These colloquium series have all come to an untimely end. The attendance by CSIR scientists at national conferences has also dropped off markedly in most disciplines.

In some national scientific societies where CSIR scientists played leading roles, they now shine by their absence. In many cases where CSIR scientists have attended symposia over the past 3 years they have made it quite clear that they see these as 'marketing exercises' only and are sometimes unwilling to have their contributions published in subsequent proceedings since this will deprive them of 'marketable data'.

These changes in the ways of thinking and in the value systems of most of the remaining CSIR scientists have resulted in their being increasingly excluded from the management of scientific societies, and from the planning of many scientific programmes, projects and conferences. These have not been conscious decisions by the South African scientific community, but a slow, natural but perceptible drift away from people who are no longer perceived as really contributing to the South African scientific enterprise in the true sense of that word.

The loss of infrastructure to the South African scientific community by the CSIR's transformation has perhaps not been that immediately obvious, but has nonetheless been substantial. What could previously have been considered to be the national science library for South Africa, the CSIR central library with its branches, is increasingly being avoided by university and other libraries. Students wishing to consult source material are being charged R25 per visit, while books borrowed through interlibrary loans are also charged for. The perception has thus been created that the CSIR library, which had been built up over decades as a national resource, now has as its main aim the servicing of in-house contract work and is no longer a national service.

Similarly, National Laboratories previously acquired capital items of which it was thought the country could afford but one, and then provided free services to the broader scientific community with these. These included expensive facilities such as advanced electron microscopes, X-ray diffraction equipment and nuclear magnetic resonance equipment. This is no longer the case and South Africa's collective research capability is suffering in consequence.

The effect of the CSIR's reorientation has had even wider attitudinal effects, difficult to quantify but nonetheless real. A limited random test amongst Ph.D. graduates in the present employ of the CSIR, not claimed to be statistically significant, but nonetheless possibly indicative of a trend, could find no individual who would advise his children to become research scientists and none who would themselves not have chosen a different career if they had had the choice. Well-publicized redundancies at the CSIR, Armscor and other statutory bodies are having a wide impact on the recruitment of undergraduate students to science. Not only is a science career now seen by students as poorly remunerative, it is also perceived as a high-risk venture.

Conclusions

Based on what has been described and propounded above, a number of tentative conclusions may be reached:

First, the management of the dramatic transformation of the old CSIR to a market-orientated, technological research establishment has been a remarkable success. The cultural reorientation achieved amongst the staff of the CSIR is truly profound.

Second, the underlying assumption in the transformation of the CSIR has been that the private sector in South Africa required, or could be convinced that it required, a substantial technological research base. It followed that commercial companies would be willing to pay for this service once the CSIR had been transformed and this to such an extent that the expected dwindling of the state subsidy could be counteracted. This has turned out to be a false assumption. Private sector companies have not rushed in to fill the gap. The new CSIR has even been perceived by the private sector, correctly or incorrectly, to be in direct, but unfair, competition with private companies.[54] The 'unleashing (of the) commercial potential of CSIR by means of technology transfer' has not yet come about.[55]

Third, whatever has been achieved in transforming the old CSIR has been at the cost of or detriment to the scientific endeavour within the CSIR and in the country as a whole. In fact, it would probably be true to say that science as a thriving, innovative intellectual enterprise within the CSIR is dead. Untold damage has been done by the abolition of national, disciplinary laboratories, the disbanding of numerous scientific units of international repute that were seen as not having a commercial market niche and the cutting short of numerous scientific careers by redundancies and early retirements. Perhaps most profoundly damaging to South Africa's science has been the transformation of scores of eminent scientists within the CSIR into junior managers and support personnel for technological investigations.

Clearly, South Africa needs a thriving, energetic and innovative technological research establishment. It also has to be admitted that it was becoming evident that after 40 years the old CSIR was not fulfilling this role well and a re-think about its purpose was in order. The manner in which the CSIR's transformation has been carried out has, however, resulted in a large part of the national scientific establishment and budget being hi-jacked for technology investigations, leaving South Africa with a one-sided, unbalanced and precarious distribution of its national science and technology resources.

Whereas the State previously had a large establishment on which to call for scientific advice and for non-remunerative projects of long duration considered in the national interest, this national ability has now to a large degree been lost. Certain research projects can still be launched within the CSIR, but scientists there are organizationally scattered, do not sit in disciplinary peer groups that effectively nourish scientific excellence and are inevitably declining in their ability to stay scientifically up to date.

This has created an empty research niche between academic research, on the one hand, and purely utilitarian investigations on the other which most other countries keep filled with national research laboratories. South Africa is the poorer for having lost this important part of its scientific research spectrum.

We believe that the demise of basic research in the national organization established for that purpose more than 40 years ago has been to the detriment of science, technological research and to the long-term detriment of South Africa's economic future.

We thank a large number of colleagues both inside and outside the CSIR for useful discussions, support and critical reviews of the manuscript on which this article is based. A number of anonymous commentators gave valuable comments.

1. Kingwill D.G. (1990). *The CSIR — The First 40 Years*. CSIR, Pretoria.
2. Carte A.E. (1989). An informal historical review of the National Physical Research Laboratory. *S. Afr. J. Sci.* 85, 76–79.
3. Anon. (1990). 'n Oorsig oor die WNNR se nuwe rol. *Sciendaba Personeeljaarverslag* 9.
4. Anon. (1987). Geldsake uit die jaarverslag. *Sciendaba* 23, 4.
5. Foster R.N. (1986). *Innovation: The Attacker's Advantage*. Pan, London.
6. Anonymous (1991). Roundtable: new challenges for the National Labs. *Physics to-day* 44, 24–35.
7. Anon. (1986). S.A's Mr Science. *Financial Mail*, supplement, 18 April, 9.
8. Garbers C. (1989). Die Afrika-dilemma: is daar hoop? *Scientiae*, Sept. 6–7.
9. Minister of Economic Affairs and Technology (1988). *Scientific Research Council Bill*, B51-88(GA), Republic of South Africa.
10. Anon. (1986). Nuwe rol vir WNNR gevra. *Die Burger*, 17 April 1986.
11. Alant T. (1987). Tegnologie in perspektief. *S. Afr. Tydskr. Natuurwet. Tegnol.* 6, 142–143.
12. Lutjeharms J.R.E. (1986). Met navorsing is S.A. soos 'n armlastige. *Die Burger*, 7 Mei 1986.
13. Gründlingh M.L. (1986). Staat al geldbron vir S.A. breintrust. *Die Burger*, 10 Mei 1986.
14. Viljoen H.C. (1986). Kwelvrae oor WNNR nog nie opgeklaar. *Die Burger*, 14 Mei 1986.
15. Hattingh H.V. (1986). Dis wat dr. Alant wou sê. *Die Burger*, 19 Mei 1986.
16. Cowley A.A. (1986). Sulke vergelykings is nie toepaslik nie. *Die Burger*, 22 Mei 1986.
17. Van der Walt P.W. (1986). Nog tyd om na WNNR te kyk. *Die Burger*, 23 Mei 1986.
18. Engelbrecht C.A. (1986). Die noodsaak van basiese navorsing. *Die Burger*, 27 Mei 1986.
19. Haarhoff P.C. (1986). Stel self vas of koning kaal is. *Die Burger*, 31 Mei 1986.
20. Viljoen H.C. (1986). Kwelvrae oor WNNR duur steeds voort. *Die Burger*, 5 Junie 1986.
21. Lutjeharms J.R.E. (1986). Knor saam oor navorsing. *Die Burger*, 13 Junie 1986.
22. Anon. (1987). CSIR takes up the challenge. *Scientiae* 28, 2–3.
23. Navorser (1988). WNNR word só as navorsingsinstansie gesloop. *Finansies & Tegniek* 40/8, 69.
24. WNNR-werknemer (1988). Storm om die WNNR. *Insig*, Feb. 7.
25. Quo Vadis: WNNR (1988). Nogmaals die WNNR. *Insig*, Maart 9.
26. Van der Merwe J. (1988). CSIR retrenches and hires. *Cape Times*, 11 January.
27. Boekkoi (sic) J. (1988). CSIR 'revolution' will produce major changes. *The Star*, 11 May.
28. Anon. (1988). CSIR; no pain, no gain. *Financial Mail*, 15 January, 72.
29. Anon. (1988). WNNR se voorbeeld. *Finansies & Tegniek*, 15 January, 7.
30. De Bruin W. (1989). Van eierdoppe en asyn tot gesogte prys. *Finansies & Tegniek* 41, 34–35.
31. Anonymous (1988). WNNR beoog groter welvaart. *Insig*, Maart, 36.
32. Van Rensburg C. (1988). WNNR: dalk te veel en te vinnig. *Insig*, Februarie, 12.
33. Smit E. v. R. (1988). Woelinge om die WNNR. *Insig*, Jan 1988, 12.
34. Anon. (1989). *Engineering Week*, February 1989.
35. Charnock H. (1988). Problems for British oceanographers. *Oceanus* 31, 78–82.
36. Maddox J. (1988). Making headway for science. *Nature* 332, 571.
37. Kenward M. (1989). Lets get back to basics, says Thatcher. *New Scient.* 124, 13.
38. Anon. (1987). Basic research takes a back seat — again. *Business Week*, 28 September, 109.
39. Hao X. (1988). PRC students abroad. *Science* 240, 968.
40. Anon. (1989). Uitslag van kommunikasie-oudit. *Sciendaba* 27, 1.
41. Anon. (1988). *CSIR Annual Report*. Council for Scientific and Industrial Research.
42. Anon. (1989). *CSIR Annual Report*. Council for Scientific and Industrial Research.
43. Anon. (1991). *CSIR Annual Report*. Council for Scientific and Industrial Research.
44. Anon. (1989). Developing a people focus. *Sciendaba*, staff annual report, Maart, 8.
45. Deming W.A. (1986). *Out of the Crisis*. Center for Advanced Engineering Study, Massachusetts Institute of Technology, Cambridge, U.S.A.
46. Peters T.J. and Waterman R.H. (1982). *In Search of Excellence*. Warner, New York.
47. Anon. (1990). *Annual Report 1989*. Industrial Technology Research Institute.
48. Drucker P.F. (1985). The discipline of innovation. *Harv. Busin. Rev.* May–June 1985, 67–72.
49. Anon. (1989). Brian Clark on RDI. *Engineering Week*, February, 1989.
50. Nayak P.R. and Ketteringham J.M. (1986). *Breakthroughs! Mercury*, London.
51. Quinn J.B. (1988). Innovation and Corporate Strategy. In *Technology in the Modern Corporation*, pp. 167–183.
52. Schmitt R.W. (1985). Successful corporate R & D. *Harvard Busin. Rev.* May–June 1985, 124–128.
53. Drucker P.F. (1977). *Management*. Pan, London.
54. Von Keyserlink C. (1990). Kommersialisering: dekmantel vir groter staatsinmenging? *Finansies & Tegniek* 44, 12–13.
55. Clark B. (1989). Can South Africa keep up? *CSIR Technology Impact* 1989, 4.